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STANDARD PATENT

Invention Title: "Improvements in Explosives"

The following statement is a full description of this invention, including the best method of performing it known to us:

TITLE

Improvements in Explosives

FIELD OF INVENTION

This invention is concerned with improvements in packaging of explosive compositions for transportation and handling.

BACKGROUND OF THE INVENTION

It is well known to package explosive compositions in purpose designed packages to assist in transportation and handling of explosive compositions including dry powder or granulated compounds, emulsions, slurries, water gels and the like.

These packages may be adapted to suit charge mass, borehole diameter, borehole length and the like.

Australian Patent Application AU-A-81802/87 describes the packaging, in non-porous plastic cartridges of from 25mm to 75mm in diameter and 1000mm long, an explosive composition comprising ammonium nitrate, paraffinic oil and foamed or expanded polystyrene beads.

British Patent 882665 describes the packaging of ammonium nitrate compositions in paper wrapped cartridges.

British Patent 1281421 also describes the packaging of an ammonium nitrate explosive in a thin flexible plastics sheath such as polyethylene. This product has a detonating cord extending throughout an elongate explosive filled sheath in a unitary charge up to 20m long. The specification discloses divisible charges in rolls of from 50m to 100m in length whereby charges of selected shorter length can be formed by clamping the sheath at closely spaced intervals and severing the charge therebetween.

The patent specification states that explosive charges according to the invention can be inserted into boreholes at up to 60° from vertical and

moreover that with the aid of a bracket shaped slide, these packages can be inserted into horizontal boreholes.

Experience has shown however that thin flexible sheaths of say 0.2mm in wall thickness are prone to perforation by puncture on rough borehole surfaces or by abrasion even on smooth borehole surfaces. If such perforations occur near the lower end of the charge being inserted, there is a risk that a substantial part of the freely flowing particulate explosive composition would fall to the bottom of the borehole beyond the end of the detonating cord without the knowledge of the personnel concerned. Only when the connected charges in adjacent boreholes were detonated would it be discovered that the mechanical and safety aspects of the integrated breaking pattern were comprised by the detonation failures in one or more boreholes.

These soft thin walled explosive packages were found to be difficult and time consuming to insert into horizontal boreholes and even more prone to puncture and tearing when pushed into the horizontal cavity.

A particular difficulty with such flexible, thin walled elongate explosive charges is that when rolled into conveniently sized coils for packaging, transportation and storage, the tubular sheath is prone to kinking or flattening in parts.

At the position of the kink or flattened region, the cross-sectional area of the explosive charge is substantially diminished and with severe kinking, a discontinuity may be formed in the mass of explosive material. This kinking or cross sectional area reduction can also occur when trying to insert elongate thin walled flexible tubular explosive charges into inclined or horizontal boreholes.

It is believed that severe reductions in cross sectional area or discontinuity in the mass of explosive composition may give rise to a condition known as "gapping" where propagation of explosive energy along the charge column is interrupted.

In order to overcome such problems with prior art packaged

explosives, particularly for use in perimeter hole blasting for tunnel shaping where the boreholes are horizontally drilled, it has been proposed to use short, rigid tubular packages adapted for end to end coupling to form a long unitary charge.

Originally such explosive packages comprised a stiff paper or cardboard cylinder about 900mm long and about 20mm diameter filled with a highly viscous, non flowable cap sensitive emulsion explosive. The paper or cardboard cylinder was open at opposite ends which were shaped to form a socket and spigot connection between adjacent packages.

Of more recent times these paper or cardboard cylinders have been replaced with a semi rigid plastics tube such as polyethylene with a wall thickness of about 1mm.

A difficulty encountered with these prior art modular explosives tubes is that a close face to face abutment of the explosive composition in adjacent tubes is required to ensure propagation of the explosive force throughout the entire assembly which may for example comprise six tubes joined by the socket and spigot fittings.

As typically these tubes are initially filled with a heated mix to reduce the viscosity of the normally non-flowable viscous emulsion, the tube contents undergo shrinkage on cooling and can create a gap of 2-3mm between the faces of explosive material when the tubes are joined.

Where "gapping" occurs between adjacent explosive masses, whether due to shrinkage in the tube or human error in assembly, an incomplete explosion can leave one or more portions of the explosive charge in the ground. This is an extremely hazardous situation with cap sensitive explosives in particular which may be accidentally detonated by impact from an excavator or subsequently in a crushing mill.

Another problem associated with prior art blasting techniques is that where it is required to increase the powder factor or energy factor in the butt" or base of a borehole, it is common practice to first push a

separate primer charge to the butt of the borehole.

Thereafter, a water gel or emulsion explosive is loaded into the borehole, typically in the form of spigot and socket joined tubes described above.

Again this procedure is prone to unreliability due to gapping between the primer and the end of the explosive charge and/or between adjacent tubes which can lead to ineffectual blasting, rifling of the borehole and unexploded explosives left in the borehole.

Yet another disadvantage associated with the abovementioned prior art explosive charges is the need to insert a stem plug to close off the borehole after the charge is loaded.

This is a costly and time consuming process.

SUMMARY OF THE INVENTION

It is an aim of the present invention to overcome or ameliorate at least some of the prior art problems associated with explosives packaged in tubular containers and/or otherwise to provide users with a convenient choice.

According to one aspect of the invention there is provided an explosive charge comprising:-

an elongate semi rigid plastics tube having a closure at each end, a detonating cord extending longitudinally within the tube between opposite ends thereof, and an explosive composition occupying a substantial volume of the interior of said tube, said tube having an enlarged distal end portion with a diameter 20% to 100% greater than the diameter of the tube.

If required, the semi rigid tube is selected from a stiffness range to permit easy insertion of the charge into horizontal or upwardly inclined boreholes.

Suitably said semi rigid tube, in use, permits formation of said charge into a coil having an inner diameter of 200mm or greater without kinking.

Suitably said semi rigid plastics tube has a wall thickness in the range of from 300μm to 1500μm.

Most preferably the semi rigid tube has a wall thickness of 800μm to 1200μm.

If required the semi rigid tube may be formed with smooth exterior and interior walls.

The semi rigid tube may be formed with a corrugated wall to facilitate coiling of a charge.

Suitably the semi rigid tube has an external diameter in the range 10mm to 50mm.

Preferably the semi rigid tube has an external diameter of from 18mm to 25mm.

The enlarged end portion preferably comprises a diameter 50% greater than the diameter of the tube.

The enlarged end portion may have an axial length in the range 100mm to 1000mm.

Preferably the enlarged end portion has an axial length in the range 200mm to 500mm.

If required the enlarged end portion may be integrally formed with the semi rigid tube.

Alternatively the enlarged end portion may be removably attachable to said semi rigid tube.

The explosive composition may be selected from flowable particulate materials, water gels or emulsions.

The explosive composition may be cap sensitive.

The tube may be sealed at opposite ends by any suitable means.

Preferably a normally distal end of the charge is sealed with a bung having a sealed cap well.

Most preferably a proximal end of the charge includes a free end of said tube to enable, in use, the free end to be folded over to form a stemming plug.

Suitably the packing density of the explosive composition is greater than 1.0 gm cm^{-3}.

According to another aspect of the invention there is provided a method of manufacturing an explosive charge, said method comprising the

steps of:-

inserting a detonator cord through a predetermined length of semi rigid plastics tube, said tube having an enlarged distal end portion with a diameter 20% to 100% greater than the diameter of the tube;

securing a distal end of said detonator cord to a closure member and inserting said closure member into a distal end of said tube;

suspending said tube from a proximal end from a filling station;

progressively filling said tube with a flowable particulate explosive composition; and,

sealing said proximal end of said tube with at least portion of said detonating cord extending therefrom.

Preferably said tube is suspended from a vibratory suspension means.

Suitably a free end of the tube extends beyond a proximal seal, to enable folding of the proximal free end, in use, to form a stem plug.

According to a further aspect of the invention there is provided a method of manufacturing a coilable elongate explosive charge, said method comprising the steps of:-

supporting on a hollow mandrel a predetermined length of semi rigid plastics tube having a closed distal end, said tube having an enlarged distal end portion with a diameter 20% to 100% greater than the diameter of the tube;

pumping a fluid explosive composition into said tube via said hollow mandrel to progressively displace said tube along said mandrel with a predetermined quantity of explosive composition; and

forming a closure in a proximal end of said tube.

If required said distal end may be closed with a closure means having a sealed cap well.

The semi rigid plastics tube may include a detonating cord

extending internally over the length of the tube.

BRIEF DESCRIPTION OF DRAWINGS

In order that the invention may be more readily understood and put into practical effect, the invention will now be described with reference to preferred embodiments illustrated in the accompanying drawings in which:-

FIG 1 shows a coilable elongate explosive charge.

FIG 2 shows a closure member for use in the charge of FIG 1.

FIG 3 shows an alternative embodiment of the invention.

FIG 4 shows schematically one method of filling a coilable explosive charge.

FIG 5 shows schematically another method of filling a coilable explosive charge.

DETAILED DESCRIPTION

In FIG 1 the explosive charge 1 comprises a 4.5m length of low or medium density polyethylene tube 2 having a wall thickness of 1.0mm.

The tube 2 is sealed at its distal end 3 with a rubber, plastics or timber bung 4 to which is attached one end of a length of detonator cord 5.

Detonator cord 5 extends throughout the axial length of tube 2 and a free end 6 extends through a closure 7 at the proximal end of the tube 2. The closure 7 is conveniently a "Tipper Tie" in the form of a metal clip extending tightly around the tube 2 to form a waterproof seal.

A particulate explosive composition which may comprise for example 90% ammonium nitrate (finely ground), 6-8% of a particulate carbonaceous fuel such as a coal dust, and 2-4% of a sensitizer such as aluminium powder, perchlorate etc.

It is to be understood that the present invention is not limited to any particular explosive composition and may comprise any known flowable

particulate explosive, water gels and emulsions.

It is to be further understood that as used herein to distinguish the opposite ends of coilable semi rigid tubular explosive charges, "distal" means the remote end of the charge, in use, closest the butt of the borehole and "proximal" means the end of the charge opposite the distal end.

The detonator cord as described above may be selected from 5gm cord for general applications or up to 10 gm cord for harder earth formations.

Typically, charges of the type described above will be used in perimeter hole blasting where horizontal boreholes are drilled for tunnel shaping etc.

The charges used for perimeter hole blasting typically are from 2 to 5 metres long but often in the range 3-4 metres.

The boreholes are usually spaced at 750-800mm from each other and may be 30-50mm in diameter.

As shown in FIG 1, a free end 8 of the tube extends beyond closure 7 for about 400mm in length. This enables the proximal free end, in use, to be folded over upon itself to form a stem plug when inserting the charge into a borehole thereby alleviating the costs associated with insertion of a separate stem plug as required with prior art charges of this type.

FIG 2 shows a preferred form of distal end closure in the form of a plastics bung 9 having a cylindrical body 10 and an end flange 11.

Apertures 12 extend through the bung 9, the purpose of which will be described later.

Also located in bung 9 is a blind bore or cap well 13 adapted to receive a detonator (not shown) but otherwise to provide a waterproof closure for use in water filled boreholes.

FIG 3 shows the bung of FIG 2 fitted to an alternative embodiment of the invention.

In this embodiment, the distal end 14 of tube 15 is radially increased from say 20mm to about 35mm over an axial length of from 100mm to 600mm to provide a charge region of increased powder or energy factor at the base or butt of a borehole.

The increased radial volume may accommodate an explosive composition having a higher explosive energy than that in tube 15 but preferably contains the same composition throughout the axial length of the charge.

In assembly of the charge, a detonator cord 16 is extended through the length of tube 15 and through one of apertures 12 and then the free end 17 of the detonator cord is inserted back through the other of apertures 12 to securely locate the cord 16 in the charge.

Bung 9 is then secured to the distal end 14 to tube 15 by heat sealing, adhesive or mechanical clamping means (not shown) before the explosive composition is inserted into the tube.

FIG 3 shows a method of manufacture of a coilable explosive charge having a flowable particulate explosive composition.

In FIG 3, a 4m length of 20mm diameter polyethylene tubing 20 first has a detonator cord 21 (shown in phantom) inserted and secured in the distal end thereof by means of a bung 22 as generally shown in FIG 2.

Tube 20 is then suspended by its proximal end in a clamping gland 23 in filling station 24 with the neck 25 of a filling hopper 26 inserted into the open end of tube 20.

Valve 27 is opened and the filling station 24, mounted on resilient mounts 28 is vibrated by a mechanical or electromechanical vibrator 29 to assist in filling the tube with a flowable particulate explosive composition 30 from hopper 26.

Vibration is important during the filling operation to not only reduce filling time but also to ensure an even packing density of the particulate explosive composition over the entire length of tube 20.

A packing density greater than 1.0 gm cm^{-3} is desirable to ensure

that the charge will not float in a water filled borehole.

When the tube 20 has been filled to a distance of about 400mm from the proximal end of the tube, valve 27 is closed and a "Tipper Tie" (Trade Mark) closure is secured around the tube 20 at the upper level of the explosive composition to form a waterproof closure about the free end of detonator cord 21 which extends from the closure.

Gland 23 is released and the tubular charge drops onto an arcuate guideway (not shown) leading on to a horizontal inspection and packing table (not shown).

The tubular charge is wound onto a mandrel of from 200-250mm diameter to form a coil having an external diameter of about 450mm which is secured with a tie or adhesive tape to prevent unravelling.

Coiled charges are then packed in boxes in multiples of four to eight for safe transport.

It will be readily apparent to a skilled addressee that the above method enables custom manufacture of tubular charges to any required length without any change in apparatus set up or procedures.

FIG 5 shows an alternative embodiment of the manufacturing process utilising a liquid or paste-like water gel or emulsion explosive.

In this embodiment a slurry pump 30 such as a "Mono" (Trade Mark) is coupled to a four metre long hollow mandrel 31 over which a hollow semi-rigid tube 32 is closely fitted.

The distal end of tube 32 is fitted with an enlarged end 33 which may be integrally formed by thermo-forming or it may be a moulded hollow body attachable to tube 32 by heat sealing, adhesive, threaded connection or the like.

A detonating cord 34 extends from a reel 35 over an idler 36 and into mandrel 31 at the base of pump 30 via a gland 37 and is connected to bung closure 38 in a manner as described with reference to FIG 3.

A liquid or paste-like explosive composition 39 is then pumped under pressure into the distal end of tube 32 and as the interior fills, tube

32 is progressively displaced along the mandrel 31 and on to inspection and packing table 40.

Again, when the explosive composition occupies all but about the last 400mm of the proximal end of the tube 32, pump 30 is stopped and a "Tipper Tie" (Trade Mark) or similar clamp is applied to the tube 32 by a clamping head 41 to form a waterproof closure about detonator cord 34 extending therefrom with an open "tail" above the closure.

After severing the detonator cord 34 and tube 32 at required positions, the process is repeated and again, it will be readily apparent to a skilled addressee that this process is readily adapted to produce explosive charges of any required length.

In the various aspects referred to above, the semi-rigid tube may be comprised of any suitable material such as plastics or rubbers including poly vinyl chloride, polyethylene, polypropylene butyl rubber or any other homopolymeric or copolymeric materials suited for the intended purpose.

While it is important that the tubular explosives charges according to the invention are not so flexible that they cannot readily be loaded into inclined or horizontal boreholes, it is equally important that they be not so stiff that they cannot be coiled without kinking into conveniently sized packages for storage, transport and handling.

The requisite properties of the semi-rigid tube may be modified by using a thinner wall with a more rigid polymer or vice versa. Similarly, increased rigidity may be imparted to an otherwise too flexible tube by incorporation of elongate ribs in the wall during manufacture by, say, extrusion.

It is preferred however that the outer wall has a smooth surface to assist in insertion in boreholes. For the dry powder explosives compositions described with reference to FIG 4, it is preferred that the interior wall has a smooth surface to avoid interference with packing of the particulate composition.

In the coiling of the elongate tubular explosive charges, it is important that the stiffness or rigidity of the tube is such that when coiled, the tube does not kink to form a reduction in cross sectional area or even a discontinuity in the mass of explosive composition as this may create a situation analogous with gapping as in prior art systems.

It is equally important that when the charge is uncoiled, there is sufficient resilient recovery that the tubular charge readily assumes a substantially straight configuration to assist in insertion in boreholes.

In the practice of the present invention, it has been found that a low-medium density polyethylene tube having an external diameter of 20-21mm and a wall thickness of 1mm can be coiled over a 200mm winding mandrel without kinking and stored for long periods of time without developing a permanent set which resists elastic recovery to a generally straight elongate tube.

CLAIMS

1. An explosive charge comprising:-

an elongate semi rigid plastics tube having a closure at each end, a detonating cord extending longitudinally within the tube between opposite ends thereof, and an explosive composition occupying a substantial volume of the interior of said tube, said tube having an enlarged distal end portion with a diameter 20% to 100% greater than the diameter of the tube.

2. An explosive charge as claimed in claim 1 wherein the enlarged end portion with a diameter 50% greater than the diameter of the tube.

3. An explosive charge as claimed in claim 1 or claim 2 wherein the enlarged end portion has an axial length in the range 100mm to 1000mm.

4. An explosive charge as claimed in claim 3 wherein the enlarged end portion has an axial length in the range 200mm to 500mm.

5. An explosive charge as claimed in any one of claims 1 to 4 wherein the enlarged end portion is integrally formed with the semi rigid tube.

6. An explosive charge as claimed in any one of claims 1 to 4 wherein the enlarged end portion is attachable to said semi rigid tube.

7. An explosive charge as claimed in any preceding claim wherein the semi rigid tube is selected from a stiffness range to permit easy insertion of the charge into horizontal or upwardly inclined boreholes.

8. An explosive charge as claimed in any preceding claim wherein said semi rigid tube, in use, permits formation of said charge into a coil having an inner diameter of 200mm or greater without kinking.

9. An explosive charge as claimed in any preceding claim wherein the semi rigid tube is formed with a smooth exterior wall.

10. An explosive charge as claimed in any one of claims 1 to 8 wherein the semi rigid tube is formed with a corrugated wall to facilitate coiling of a charge.

11. An explosive charge as claimed in any preceding claim wherein the semi rigid tube has an external diameter in the range 10mm to 50mm.

12. An explosive charge as claimed in claim 11 wherein the semi rigid

tube has an external diameter of from 18mm to 25mm.

13. An explosive charge as claimed in any preceding claim wherein said semi rigid plastics tube has a wall thickness in the range of from 300Fm to 1500Fm.

14. An explosive charge as claimed in claim 13 wherein the semi rigid tube has a wall thickness of 800Fm to 1200Fm.

15. An explosive charge as claimed in any preceding claim wherein the explosive composition is selected from flowable particulate material, water gels or emulsions.

16. An explosive charge as claimed in any preceding claim wherein the explosive composition is cap sensitive.

17. An explosive charge as claimed in any preceding claim wherein the tube is sealed at opposite ends.

18. An explosive charge as claimed in any preceding claim wherein a distal end of the charge is sealed with a bung having a sealed cap well.

19. An explosive charge as claimed in any preceding claim wherein a proximal end of the charge comprises a free tail of said tube to enable, in use, the proximal free end to be folded over to form a stemming plug.

20. An explosive charge as claimed in any preceding claim wherein the packing density of the explosive composition is greater than 1.0 gm cm^{-3}.

21. A method of manufacturing an explosive charge as claimed in any one of claims 1 to 20, said method comprising the steps of:-

inserting a detonator cord through a predetermined length of semi rigid plastics tube;

securing a distal end of said detonator cord to a closure member and inserting said closure member into a distal end of said tube;

suspending said tube from a proximal end from a filling station;

progressively filling said tube with a flowable particulate explosive composition; and,

sealing adjacent said proximal end of said tube with at least portion

of said detonating cord extending therefrom.

22. A method as claimed in claim 21 wherein said tube is suspended from a vibratory suspension means.

23. A method as claimed in claim 21 or claim 22 wherein portion of the proximal end of the tube is left as a free tail, to enable folding of the free proximal tail, in use, to form a stem plug.

24. A method of manufacturing an explosive charge, said method comprising the steps of:-

supporting on a hollow mandrel a predetermined length of semi rigid plastics tube, said tube having a closed enlargd distal end portion with a diameter 20% to 100% greater than the diameter of the tube;

25. A method as claimed in claim 24 wherein said distal end is closed with a closure means having a sealed cap well.

26. A method as claimed in claim 24 or claim 25 wherein the semi rigid plastics tube includes a detonating cord extending internally over the length of the tube.

27. An explosive charge substantially as hereinbefore described with reference to FIG 1 to FIG 3 of the accompanying drawings.

28. A closure member for an explosive charge according to any one of claims 1 to 21 substantially as hereinbefore described with reference to FIG 2 of the accompanying drawings.

29. A method for manufacturing an explosive charge substantially as hereinbefore described with reference to FIG 4 of the accompanying drawings.

30. A method for manufacturing an explosive charge substantially as hereinbefore described with reference to FIG 5 of the accompanying drawings.

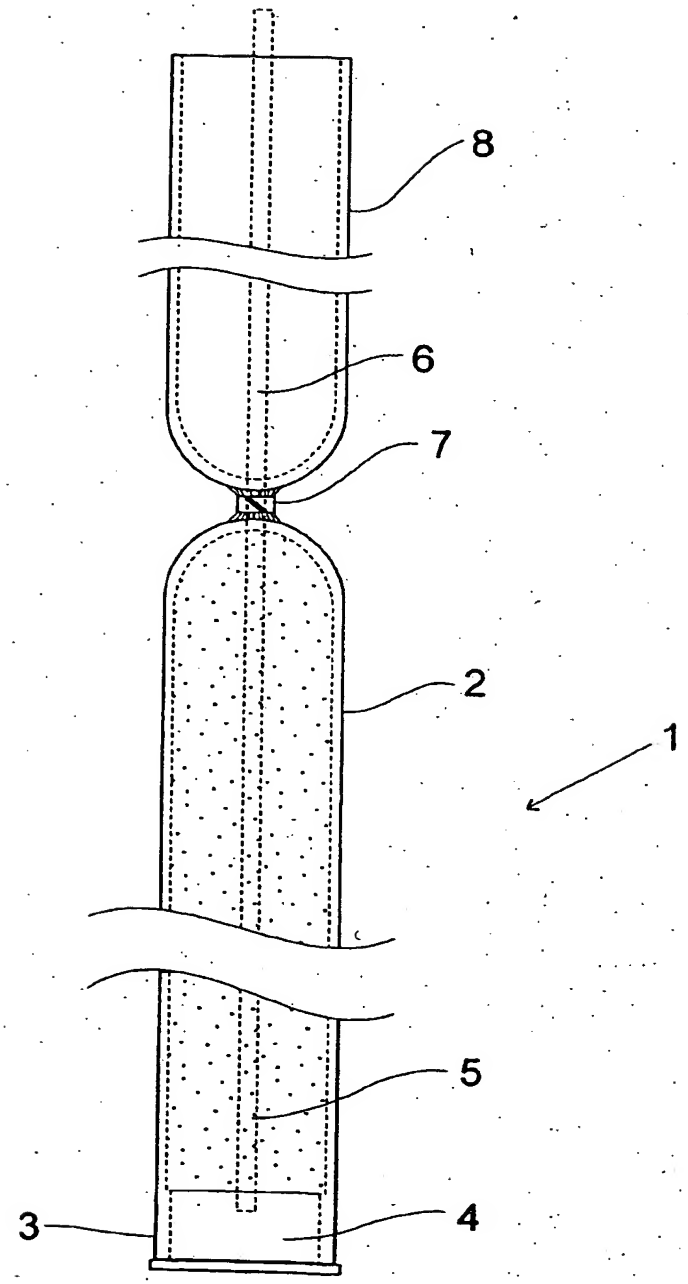

FIG. 1

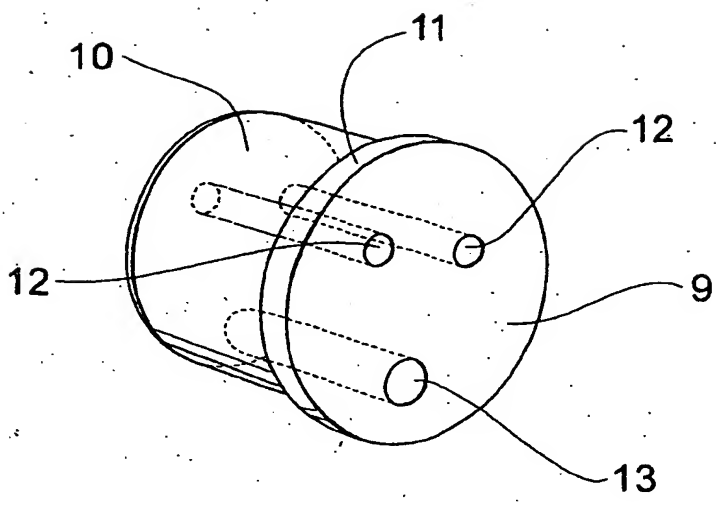

FIG. 2

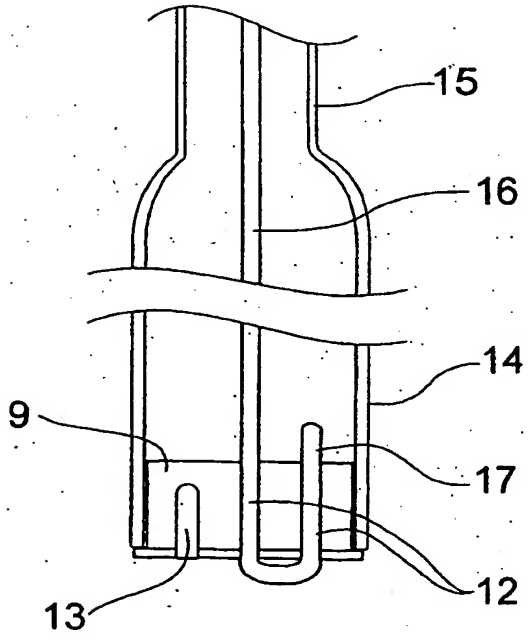

FIG. 3

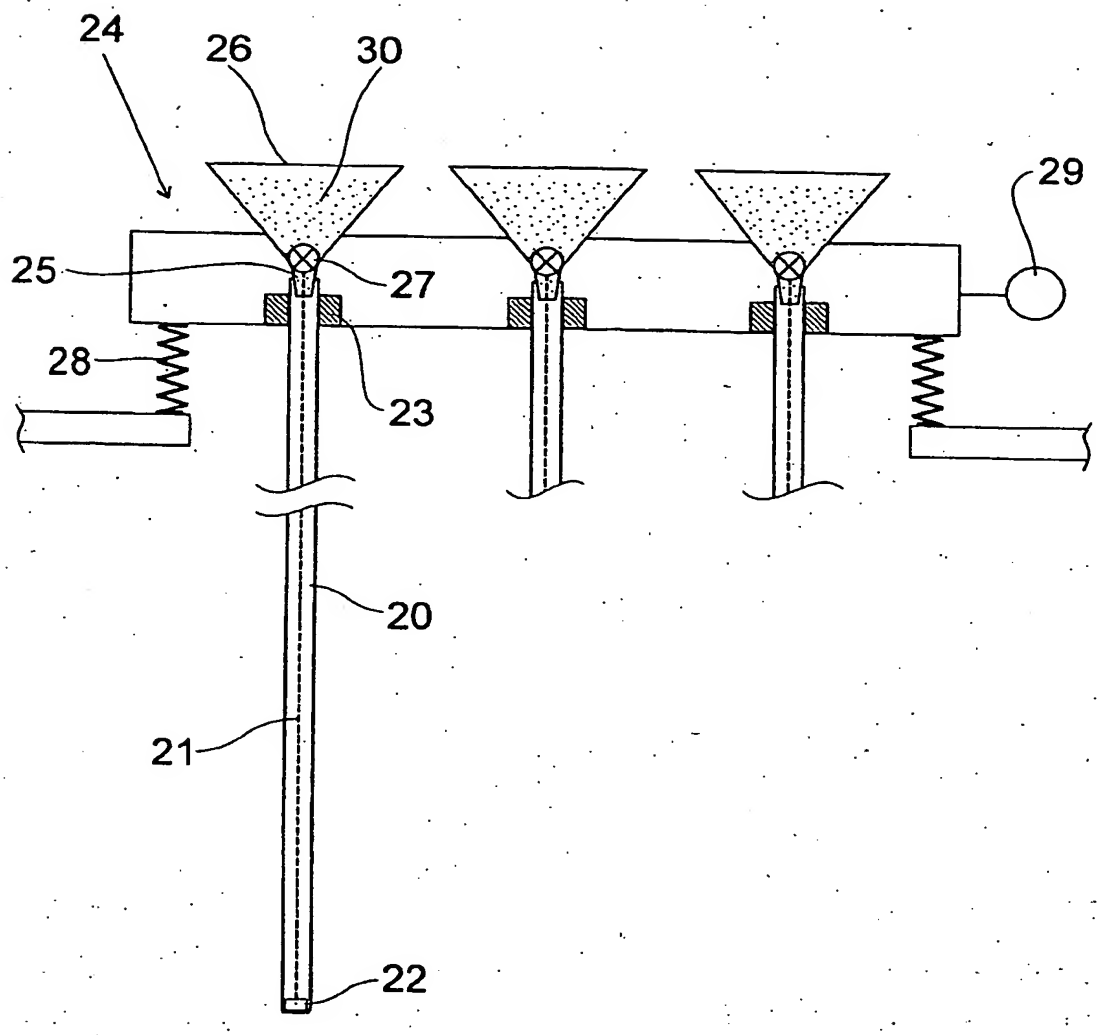

FIG. 4

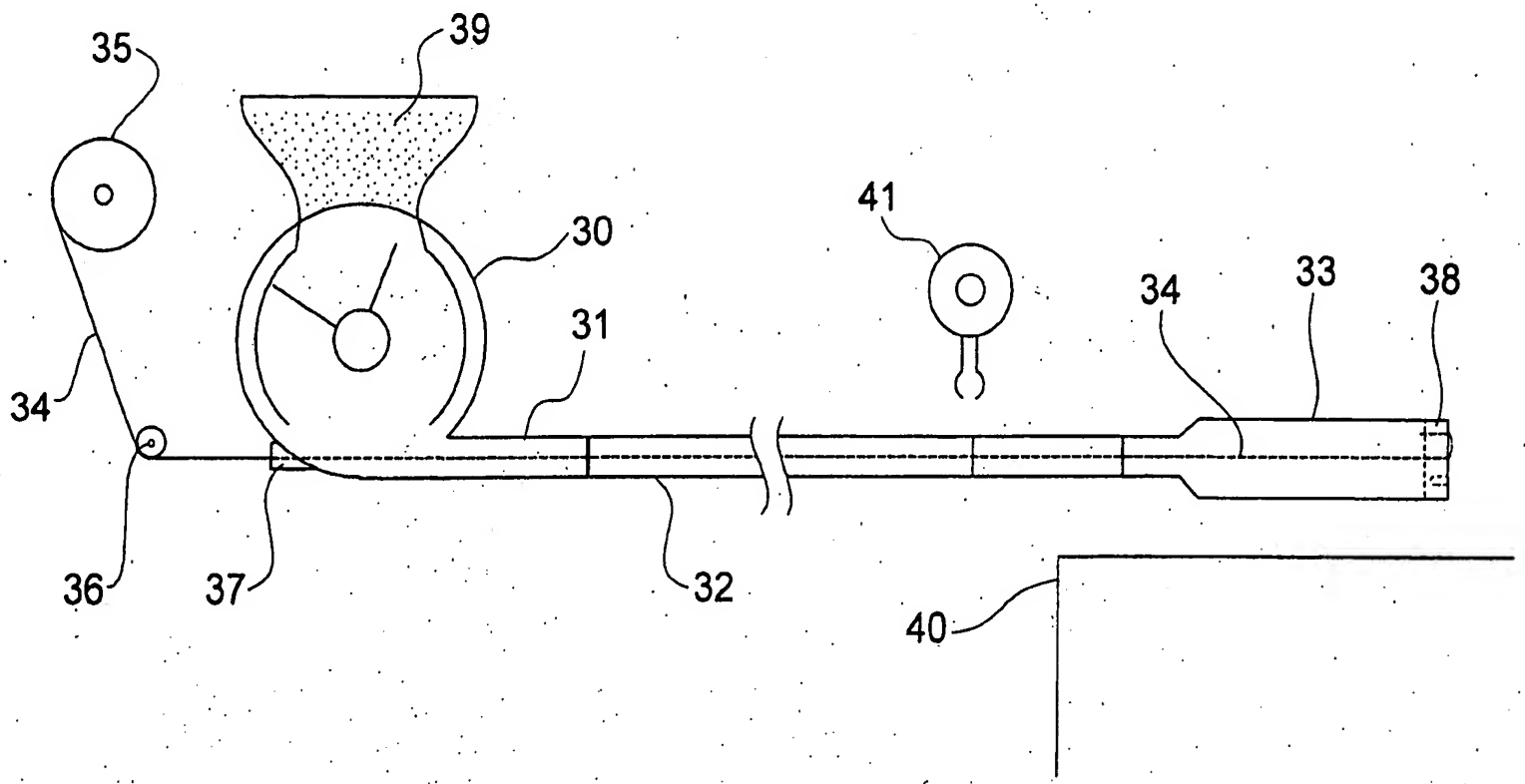

FIG. 5